

IN 1211.9-1

MODEL 354A

DIGISET

DIFFERENTIAL CONTROLLER

INTRODUCTION

This instruction manual is designed to help you secure maximum benefits from your new Model 354A Digiset. It should be given to persons responsible for installation and maintenance of this instrument.

Your Barber-Colman factory trained field engineer is always available for further help in the solution of your control problems. Offices are located in all principal cities.

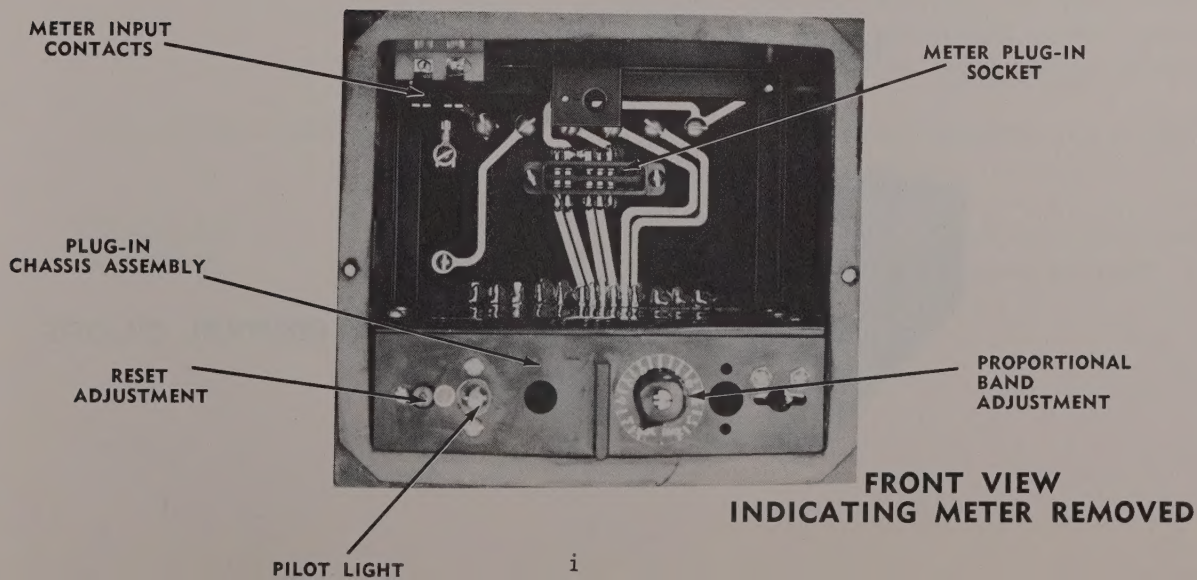
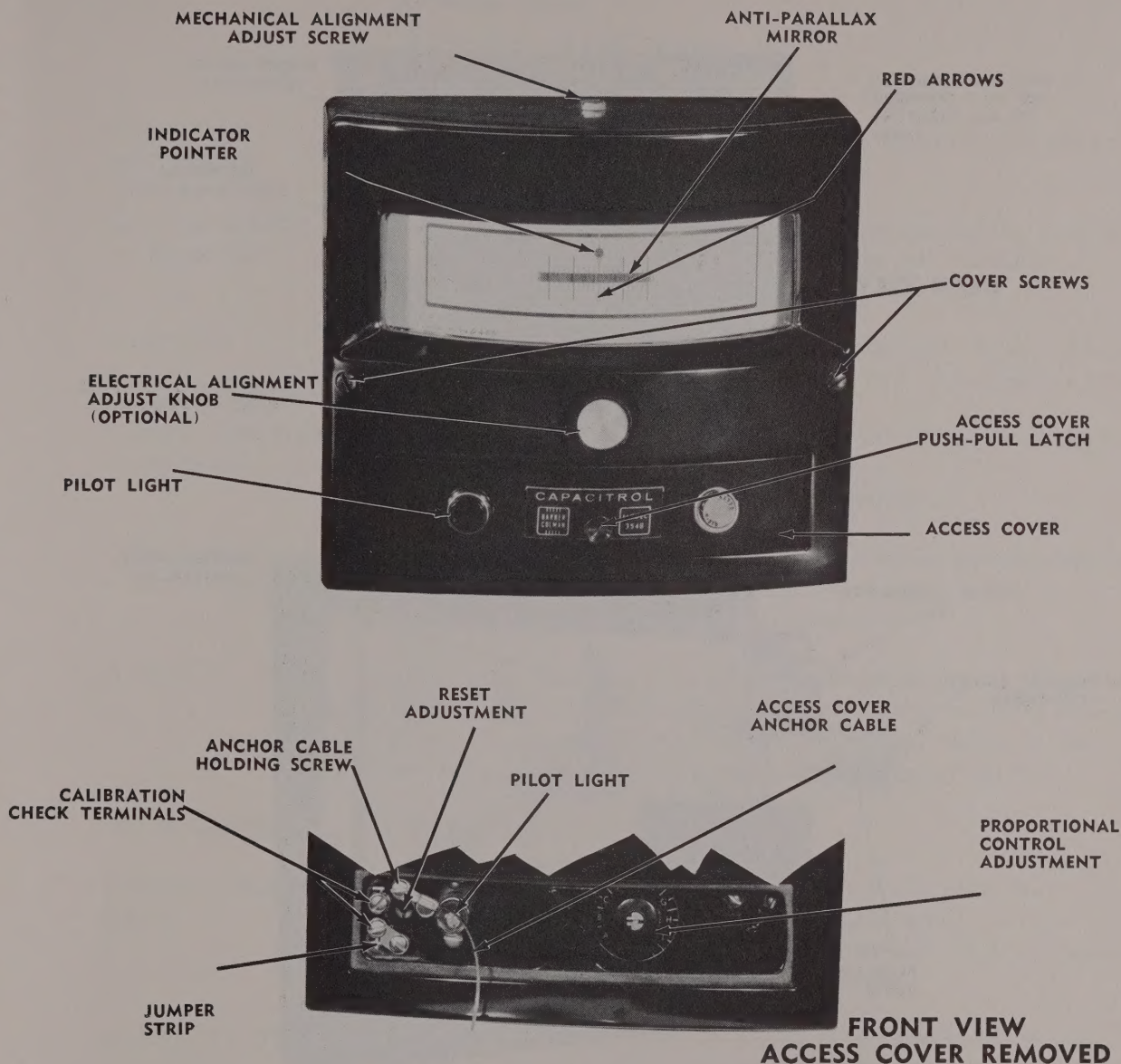
BARBER-COLMAN COMPANY
Industrial Instruments Division

MODEL 354A INSTRUCTION MANUAL

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MODEL 354A DIGISET



GROUND TERMINAL
(DO NOT CONNECT
TO A.C. NEUTRAL
LINE)

SHUNT WIRE
FOR SHIPPING ONLY
REMOVE BEFORE USE

METER INPUT
TERMINALS

EXTERNAL
RESISTANCE STRIP

REAR VIEW

POWER AND CONTROL
CIRCUIT TERMINALS

METER ALIGNMENT
PIN

AUTOMATIC SHUNT
CONTACTS

METER
PLUG-IN
STRIP

METER INPUT
CONTACTS

INDICATING METER ASSEMBLY

CONTROL CHASSIS

DEFINITION OF TERMS

CONTROL SET POINT	The position on the instrument scale to which the control point setting mechanism is set.
CONTROLLED VARIABLE	That quantity or condition which is varied by the controller so as to affect the power of the measured variable. Example: Power to an electric furnace.
CYCLING	A periodic change of the measured variable from one value to another. <u>Oscillation</u> and <u>hunting</u> are synonymous terms.
FINAL CONTROL ELEMENT	That portion of a control system which directly changes the value of the controlled variable. Example: Model 621A Power Controller.
MEASURED VARIABLE	That quantity or condition which is measured and regulated through control of the controlled variable. Example: Temperature in a furnace.
OFFSET	A sustained deviation from control point due to proportional control action. It is the difference existing at any time between control point and the actual value of the measured variable. <u>Droop</u> is a synonymous term.
OSCILLATION	See <u>Cycling</u> .
PROPORTIONAL BAND	That change in value of the measured variable that is necessary to cause full travel of the final control element. It is measured as a percent of full scale span. <u>Throttling range</u> is a synonymous term.
PROPORTIONAL CONTROL	Controller action in which there is a continuous linear relation between the value of the measured variable and the position of the final control element. In other words, the output of the controller is proportional to its input. Synonymous terms are <u>throttling</u> or <u>modulating</u> action.
RESPONSE TIME	The time for the meter indicator to reach 63.2% of the final value after a step change input.
CRITICAL DAMPING	That condition of damping in which the meter movement reaches the point of equilibrium in the least possible time without overshoot.

MODEL 354A SPECIFICATIONS

Meter

Scale Length	1.25" or 20 divisions; 1 division = 1/16"
Sensitivity	0.70 micro amperes per division (nominal)
Internal Coil Resistance	95 ohms (nominal)
Critical Damping Resistance (added externally -- standard meters only)	325 ohms (nominal)
Response Time	

Standard Meters:

Critically Damped	1.4 seconds (nominal)
Meter Coil only	5.5 seconds (nominal)
Meters with Electrical Alignment	

Chassis

Control Output	Direct current
Control Output Span	2 to 12 milliamperes into 1500 ohm load
Proportional Band	Adjustable from 2% to 16% of graduated scale length (16% of scale length = 3.2 divisions; 2% of scale length = 0.4 divisions)
Control Adjustment	Reset control internally adjustable
Power Requirements	9 volt amperes
Power Supply	110-130 volts a-c, 50/60 cycles

Dimensions and Weights

Overall Dimensions	6 7/8" wide x 6 1/4" high x 9 5/8" deep
Cutout for Flush Mounting	6 1/8" wide x 5 9/16" high Note: Meter housing will extend approximately 7 1/4" into panel when flush mounted
Weights	Net weight approximately 9 pounds Shipping weight approximately 14 pounds

MODEL 354A INSTRUCTION MANUAL

DESCRIPTION

General Description and Application

The Model 354A is a millivoltmeter-type differential controller with a proportional d-c current output. It responds to the millivoltage difference from two thermocouples wired in series opposition, or to the input from one thermocouple compared to a reference voltage, and indicates this difference by pointer deflection either to the right or left of scale center. The Model 354A then delivers an output signal suitable for the proportional control of pilot amplifier/saturable reactor systems or silicon controlled rectifier power controllers.

The differential control principle of this instrument is utilized, as an example, to control one of the end zones of a three zone furnace, maintaining the temperature at the same level as the center zone. The Digiset will perform as a null balance controller when used with a Series 350 Reference Voltage Source, or as a null balance program controller when used with a Series 350/360 combination.

The instrument is equipped with a mechanical screw adjustment to align the meter indicator with the red pointers in the center of the scale. A "null" condition is then produced when there is no temperature difference between the two thermocouples, or when there is no output difference between one thermocouple and a reference voltage source. As an option the meter may be furnished with a bridge circuit for electrical alignment adjustment, in addition to the mechanical adjustment, which is used to compensate for thermocouple inaccuracies.

NOTE: Instruments not equipped with the electrical alignment feature are referred to as "standard" models in this manual. All instructions apply to both variations unless otherwise stated.

Control Specifications

As stated above, the Model 354A Controller has a proportional direct current output for controlling magnetic amplifiers or silicon controlled rectifier power controllers. Magnetic amplifiers are generally used to control saturable core reactors, which in turn regulate the load power. The output range of the Model 354A is 2 to 12 milliamperes and is designed to be used with a 1500 ohm load. Two adjustments, "Proportional Band" and "Reset" are adjustable from the front of the instrument. The proportional band is adjustable from 2% to 16% of graduated scale length. The control point is set so that when the meter

indicator coincides with the red arrows in the center of the scale, the output of the instrument is approximately 7 milliamperes. If the load requirements are other than this the offset or deviation between the red arrows and the meter indicator is adjusted with the reset adjustment as described in a later section of this manual.

The red signal light indicates that power is applied to the chassis. The output terminals are terminals 5 and 6, with terminal 5 of negative polarity and terminal 6 positive.

Description of Electronic Circuit

The Model 354A incorporates a transistorized oscillator and a d-c amplifier. At a position to the left of the red arrows, the collector current of the oscillator transistor is of sufficient magnitude so that the output of the d-c amplifier is greater than 12 milliamperes. As the indicator approaches the red arrows, a small vane or flag suspended from the indicating pointer passes between two flat coils, reducing the collector current of the oscillator transistor. With the flag fully between the coils, the collector current is decreased to a minimum so that the output of the d-c amplifier is less than 2 milliamperes. Proportional control action occurs when the flag traverses a fixed distance between the coils. The position of the flag within the coils, therefore, varies the collector current which then proportionately controls the amplifier output. The proportional band is made larger or smaller by adjusting the level of feedback from the d-c amplifier to the oscillator, regulating the oscillator collector current change with respect to flag movement. When there is no feedback the proportional band is at minimum, or 2% of graduated scale length, and at maximum feedback the proportional band is increased to 16% of graduated scale length or greater.

Proportional Control

Within the proportional band, the Model 354A will supply an output to an external power controller which is proportional to temperature deviation. Barber-Colman external power controllers are generally designed so that when 12 milliamperes are supplied from the controlling instrument, maximum power is applied to the load, and when 2 milliamperes are supplied, minimum (or zero) power is applied to the load. A means of close tolerance control of load power, with minimum overshoot and undershoot, is therefore obtained.

Figure 1 is an example showing the instrument's proportional band curves for a 16% proportional band setting and a 2% proportional band setting. The 16% proportional band setting is obtained by turning the proportional band adjustment fully clockwise. Also, in Figure 1 are the 620 Series and Model 610A power transfer curves. The power transfer curves also assume that the input control winding resistance of the 610A and 620 Series is 1500 ohms. The curves give a relative indication of power output. For example, if a voltmeter was attached to the test jacks and the meter read 12 volts (8 ma with 1500 ohm load), the 620 Series power output would be 60% of maximum output power. If a Model 610A was used the output of the 610A would be about 42.5 volts d-c, which would be the input to a reactor used in conjunction with the 610A magnetic amplifier.

As shown in the example, the meter would indicate about 0.3 of a division to the left of the red arrow. This offset is corrected using the reset adjustment as described under "Control Adjustments". The example shows the proper reset adjustments for the particular control point selected. In this example, the power transfer curves would also be shifted over the same amount as the proportional band curve.

To obtain the number of degrees (Fahrenheit or Centigrade) represented by the effective proportional band, the two examples discussed in the section entitled "External Resistance" are utilized:

For a proportional band setting of 16% of scale length, the proportional band in °C for the two examples would be:

Meter coil only (not critically damped)

$$4.9^{\circ}\text{C}/\text{division} \times 16\% \times 20 \text{ divisions}/\text{scale length} = 15.7^{\circ}\text{C}$$

This means that a 15.7°C change in temperature will change the control output current from 12 to 2 milliamperes in the proportional band operating range.

Critically damped:

$$21.5^{\circ}\text{C}/\text{division} \times 16\% \times 20 \text{ divisions}/\text{scale length} = 68.8^{\circ}\text{C}$$

For proportional band setting of 2% of scale length:

Meter coil only

$$4.9^{\circ}\text{C}/\text{division} \times 2\% \times 20 \text{ divisions} = 1.96^{\circ}\text{C}$$

Critically damped

$$21.5^{\circ}\text{C}/\text{division} \times 2\% \times 20 \text{ divisions} = 8.6^{\circ}\text{C}$$

In some cases the temperature change that is required to change the controller output from 12-2 ma might not be sufficient for adequate control. If this is the case, by increasing the external resistance strip value, thereby increasing the total external resistance, the effective proportional band related to temperature change will be increased or the meter sensitivity decreased. Generally, the maximum proportional band should be equal to a temperature change of 5% of temperature span to insure adequate control. The temperature per division can then be obtained for a maximum proportional band condition by dividing 5% of the temperature span by 3.2 giving the temperature per division. The external resistance needed can then be determined from the nomograph on page 19.

In using the 354A in control systems, the proportional control of load power is obtained by using the direct current output of the 354A to control a pilot amplifier/saturable reactor combination, or a Series 620 "SCR" power controller. The external wiring diagrams show typical connections. If reactors are used to control load power, a shunting resistor should be connected directly across the reactor control winding terminals, as shown, in order to protect the reactor control winding in case the control circuit is opened under load, inducing a high voltage in the control winding.

As can be seen in Figure 1, there is always a small output when using a Model 610A Pilot Amplifier to drive a reactor. This results in a small amount of power always being applied to the load, even when the instrument's output is less than 2 milliamperes. Two types of pilot amplifiers are available for the pilot control reactors: The Model 610A -- a magnetic amplifier, and the Model 630A -- an SCR type controller with a d-c output. The specifications are as follows:

Model 610A

Excitation 120 v, 60 cycle;
output - 5-75 v d-c, maximum
power output to reactor control
windings - 188 va. Used with
reactors up to 30 kva rating.

Model 630A

Excitation 120 v, 60 cycle;
output - 0-80 v d-c, maximum
power output to reactor control
windings - 750 va. Used with
reactors up to 130 kva rating.

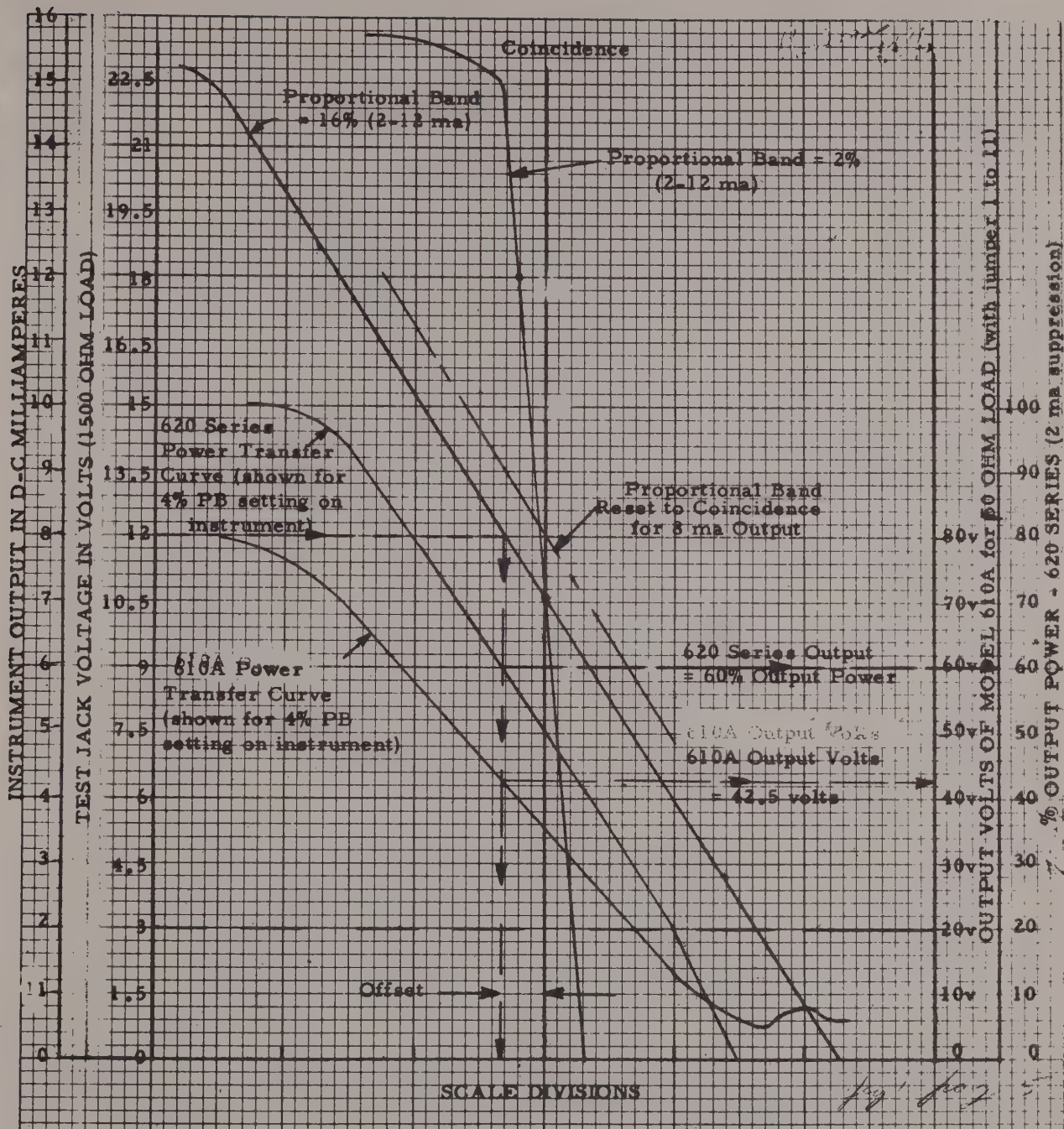


Figure 1
Example of proportional control action as the meter indicator moves to the right through the proportional band

INSTALLATION

Unpacking the Instrument

This precision instrument and its associated equipment have been carefully manufactured and packed at the factory. Remove the instrument and accessories from the packing box and check items against the packing slip. If the equipment is found to be damaged in transit, report damages to the carrier immediately. Repack in original packing box until ready for installation.

CAUTION:

Handle with care.

Safeguard instrument from shock before and after installation.

Avoid oil accumulation and exposure to moisture.

Keep instrument temperature under 130°F and over 40°F.

Mounting Instructions

Locate instrument to avoid excessive vibration, shock and temperatures outside the range of 40°F to 130°F. Avoid furnace walls, radiation of heat, machine frames, and outside walls. Provide suitable shelter against moisture and temperature extremes if installed outdoors. Refer to appropriate drawing for mounting details.

Power Wiring

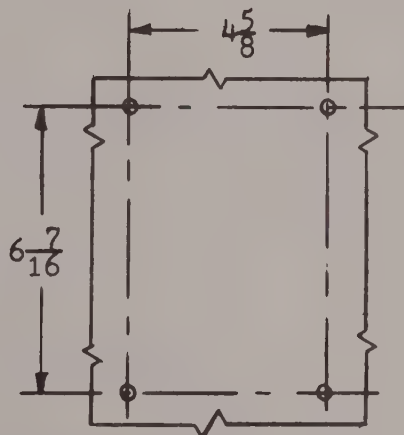
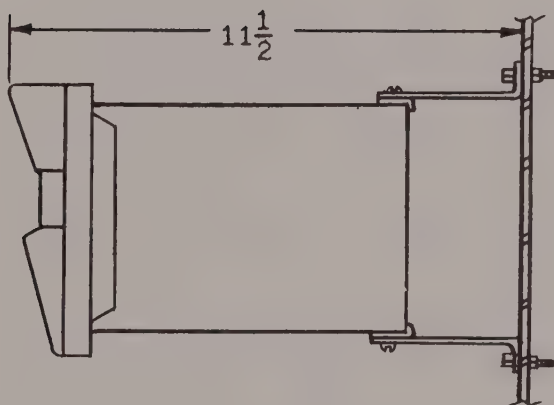
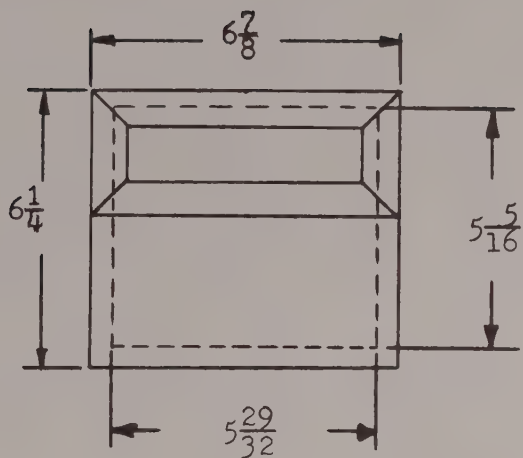
The Model 354A is to be powered from 120 volt, 50 or 60 cycle a-c systems. The a-c supply voltage is connected to terminals L1 and L2 on the back of the instrument housing. All wiring should be in accordance with the applicable electrical codes. Where maximum protection of the instrument is desired, a 1/8 ampere fuse may be added in the power line to the instrument.

The instrument should be grounded. This is accomplished by attaching the ground terminal directly to a good ground, such as a cold water pipe.

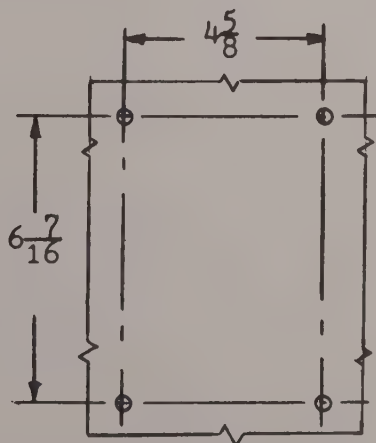
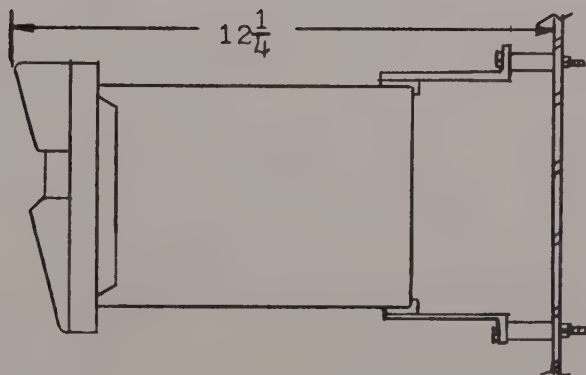
CAUTION:

Do not connect the GRD terminal to the neutral a-c line.

FRONT VIEW AND
CASE DIMENSIONS



SURFACE MOUNTING DIMENSIONS



VIBRATION MOUNTING ARRANGEMENT FOR SURFACE MOUNTING

Figure 2

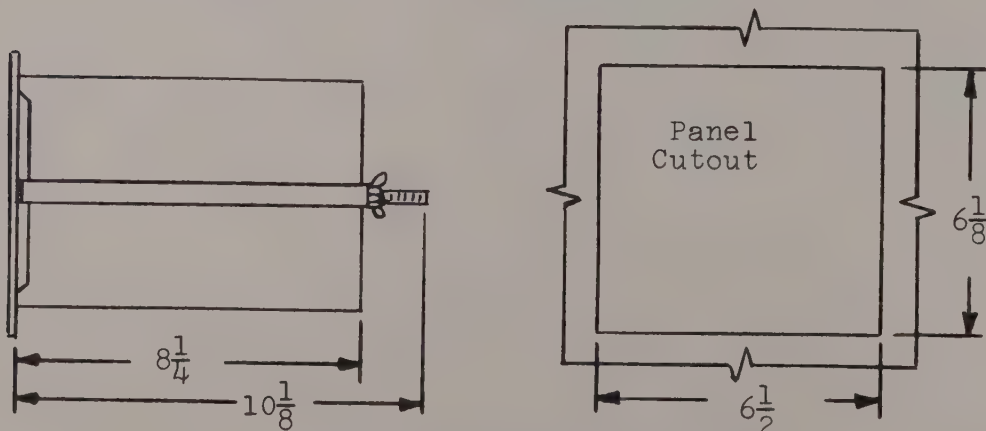
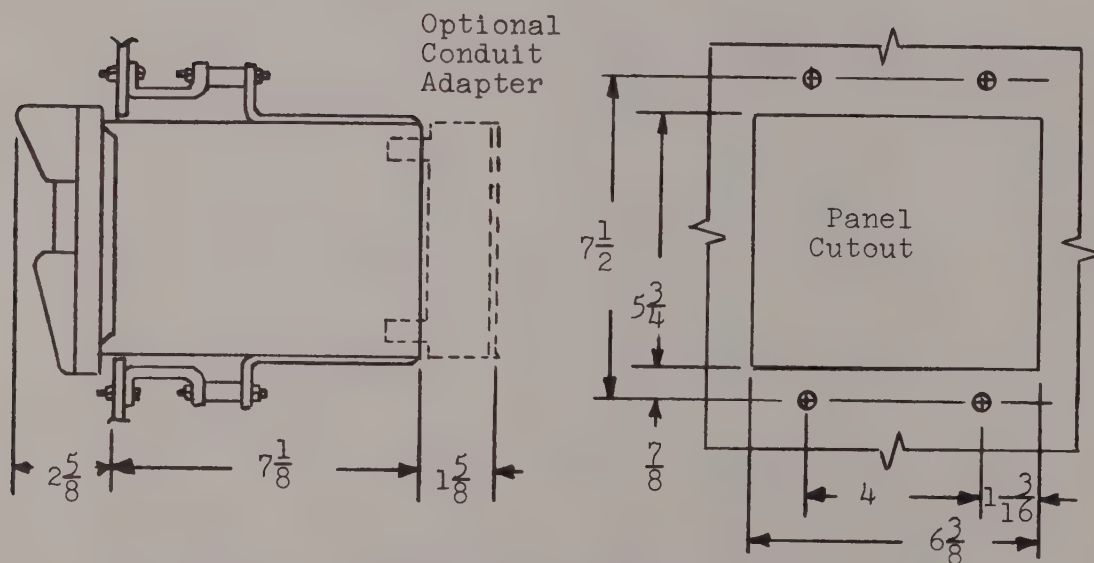
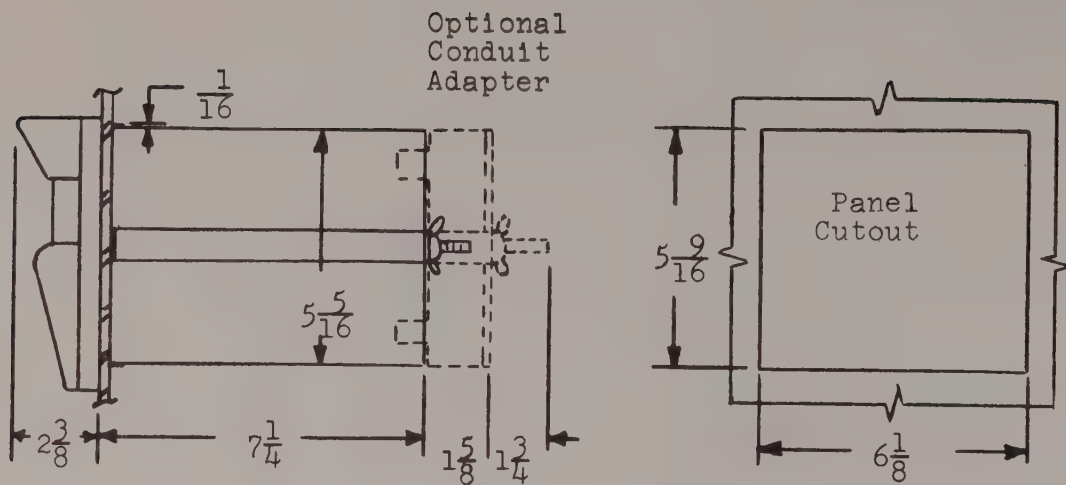


Figure 3

Terminals 5 and 6 are wired internally to the control chassis to obtain a d-c output current. Terminal 6 is the positive terminal, and terminal 5 is the negative terminal. The external wiring diagrams show some typical wiring diagrams.

Meter Shunt Wire

After the instrument is installed, disconnect the jumper wire across terminals marked "Shunt", "TC-" and "TC+" on the back of the instrument. This wire is used to shunt or dampen the meter movement for protection during shipping, handling and installing the instrument, but should be removed for normal operation.

If the meter assembly is removed from the case, the automatic shunt device protects the meter assembly from damage. Shunt wiring is not required.

Thermocouple Wiring

Do not run thermocouple extension wire with other power or control wiring. Several thermocouple extension wires may be run in the same conduit, however.

Use only extension wire correct for the type of thermocouple (TC) as specified on the scale. The types most commonly specified are:

Iron-Constantan	Type J
Chromel-Alumel	Type K
Platinum-Platinum 10% Rhodium	Type S
Platinum-Platinum 13% Rhodium	Type R

Ordinary copper wire must not be used as extension wire. Consult your Barber-Colman field office for a selection of thermocouple assemblies and extension wire.

Single Thermocouple:

When using a single thermocouple with a reference voltage source, connections are made between the thermocouple head and the terminal board on the reference voltage source, plus to plus and minus to minus -- using the proper polarity and calibration of extension wire. Color coding -- red -- indicates the negative wire. See external wiring diagrams. If connections are made correctly, the indicating pointer will move to the right when the thermocouple hot junction is heated. If it does not, reduce the millivoltage of the reference source to a minimum, disconnect the thermocouple, twist the ends of the extension wire together and heat this junction to a temperature sufficient to cause meter deflection. A left-to-right deflection of the indicator pointer is proof of correct polarity

of the extension wire, which means that the connections at the thermocouple head were reversed.

Two Thermocouples:

When two thermocouples are used for differential control, connections should be made as shown in Figure 4.

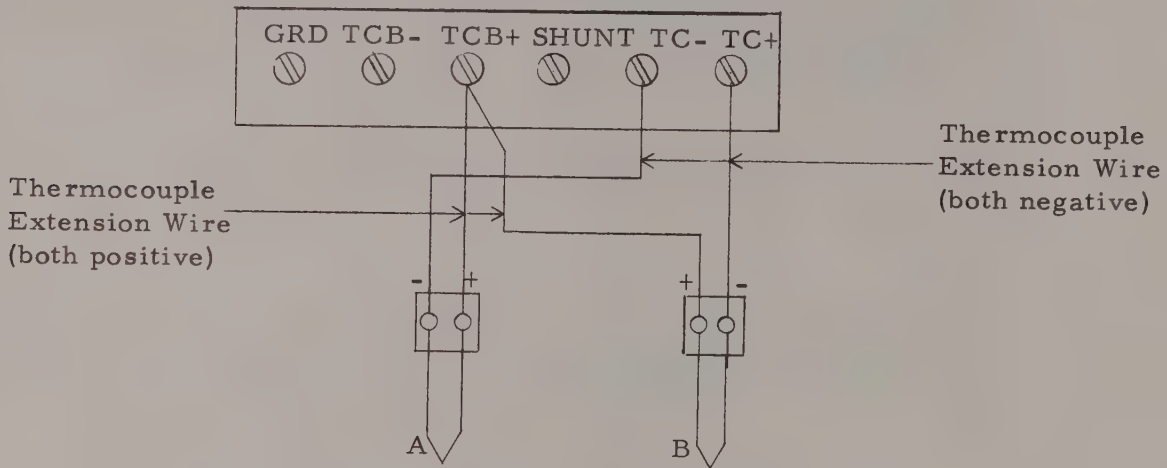


Figure 4

The positive terminals of the two thermocouples should be interconnected at the instrument using extension wire from the plus terminals of the thermocouple head to the TCB+ terminal on the strip at the back of the instrument panel. (NOTE: Thermal voltage variations appearing as temperature drift at the meter may result if thermocouples are directly connected one to the other). The negative terminals of the thermocouples are connected to TC- and TC+ on the instrument terminal panel. Make certain that extension wire of correct polarity is used as shown in Figure 4. To determine that connections are made properly, heat thermocouple A to a higher temperature than thermocouple B. The meter indicator should then move to the right of the center arrows decreasing the d-c current output. Conversely, when thermocouple B is at the higher temperature, the meter indicator will move to the left, increasing the output. (NOTE: In a typical installation, thermocouple A would be placed in the end zone of a three zone diffusion furnace and thermocouple B in the center zone).

Electrical Alignment Option:

Figure 5 shows the thermocouple wiring arrangement to be used for instruments equipped with the electrical alignment adjustment feature (identified by the knob on the front of the meter). Although connections are different, polarity can be checked in the same manner as described in the preceding paragraph.

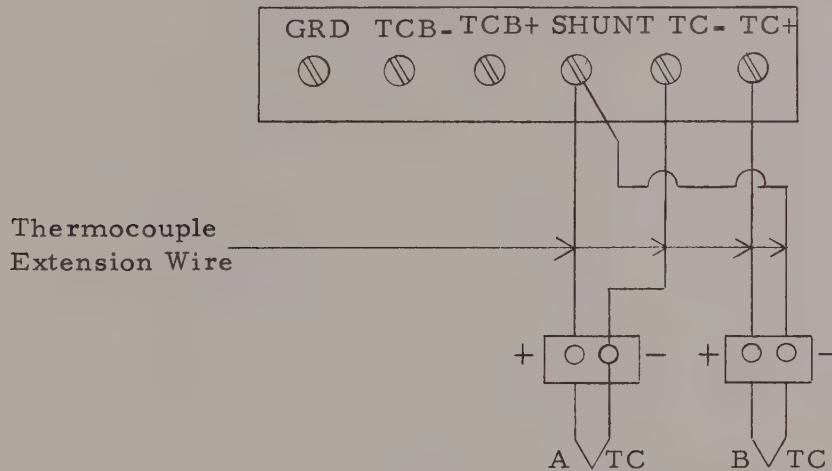
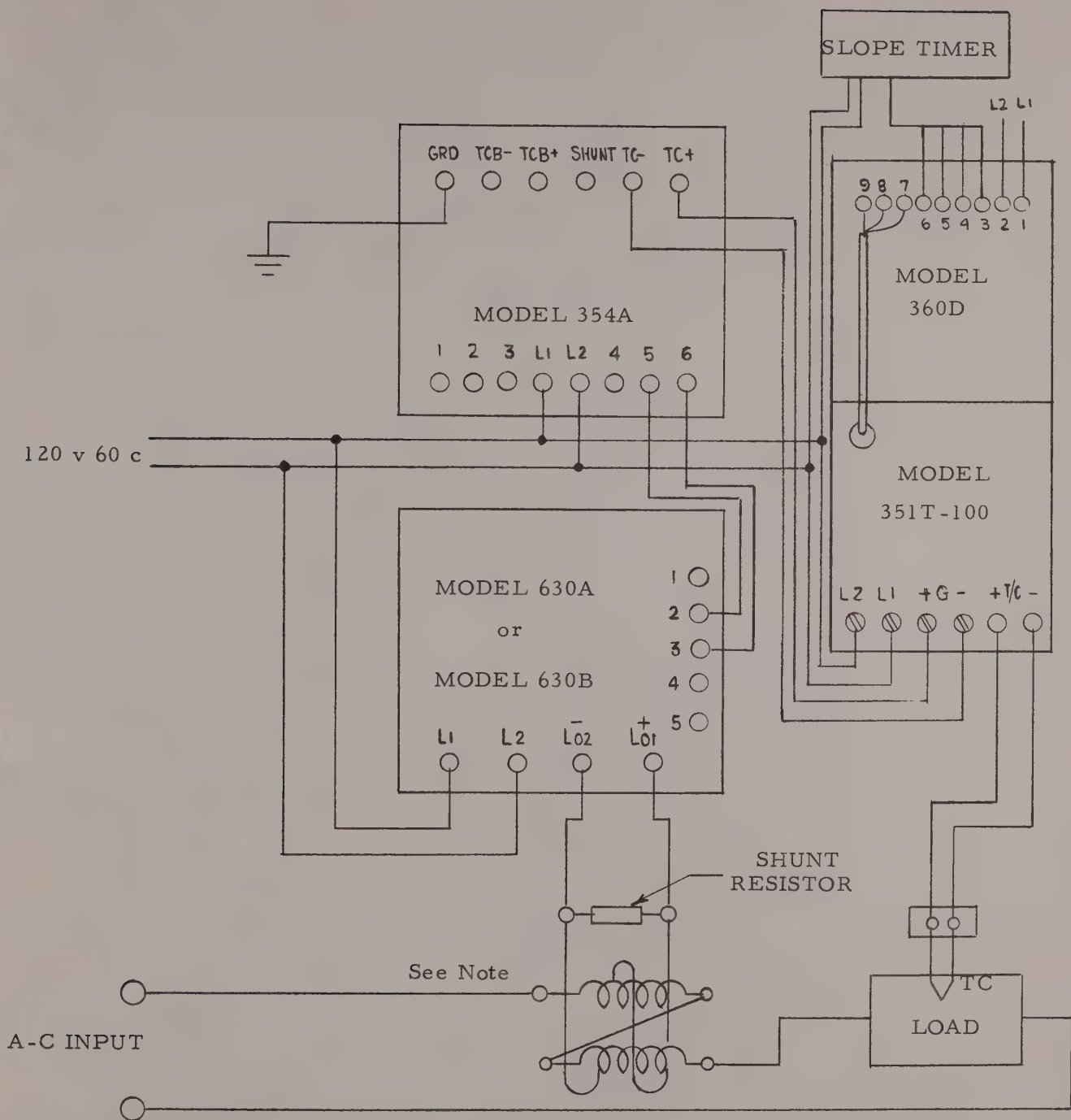


Figure 5

Secure the leadwires firmly under the terminal screws. If desired, spade lugs may be used.



NOTES:

1. Reactor coil may be parallel connected for lower line voltage. Refer to manufacturer's specifications.
2. Identification of control winding terminals differ with various manufacturers.

Figure 7

External wiring diagrams showing the Model 354A with Series 350 Reference Voltage Source and Series 360 Programmer for program control of a Model 630A Pilot Amplifier and Saturable Core Reactor

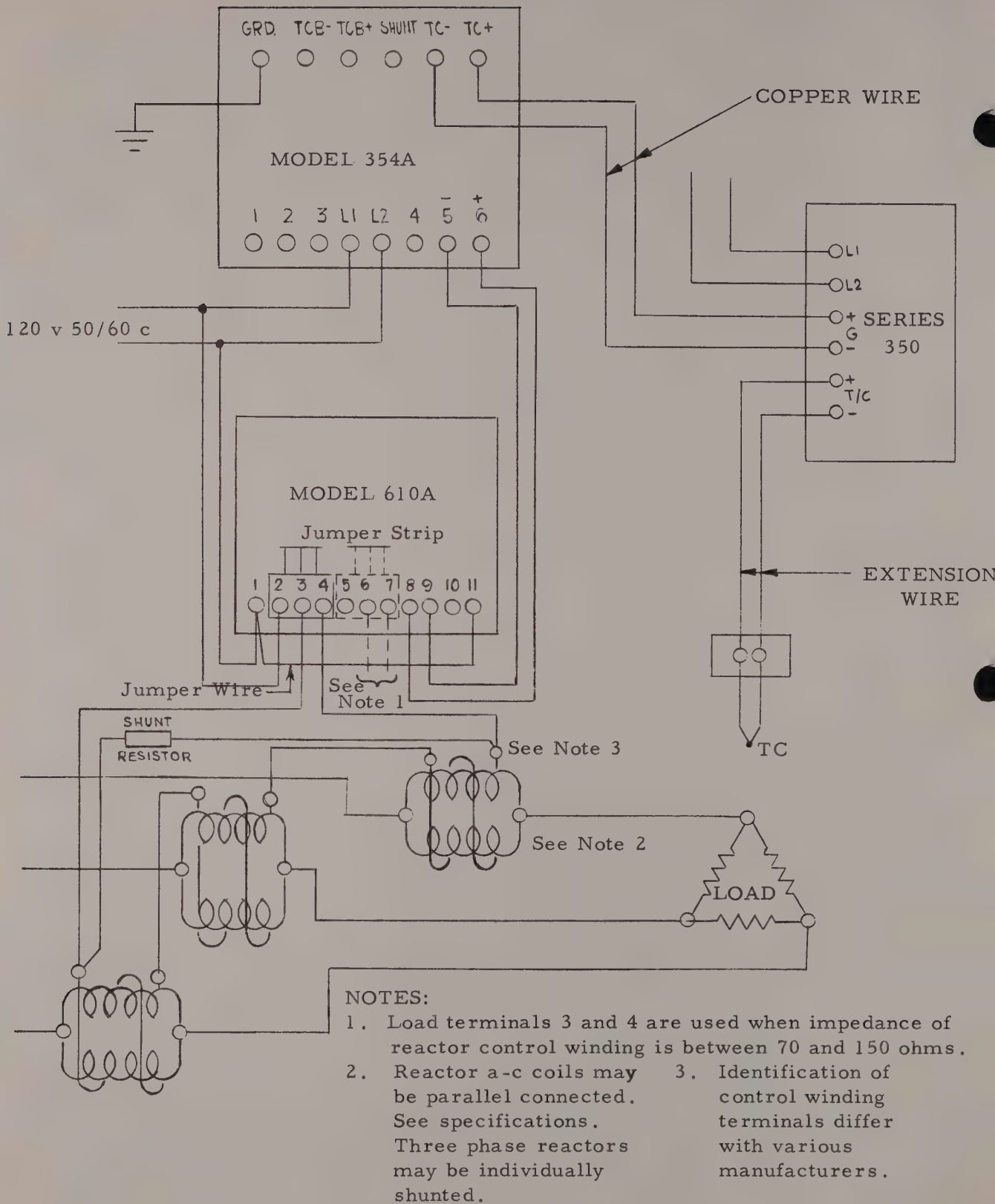
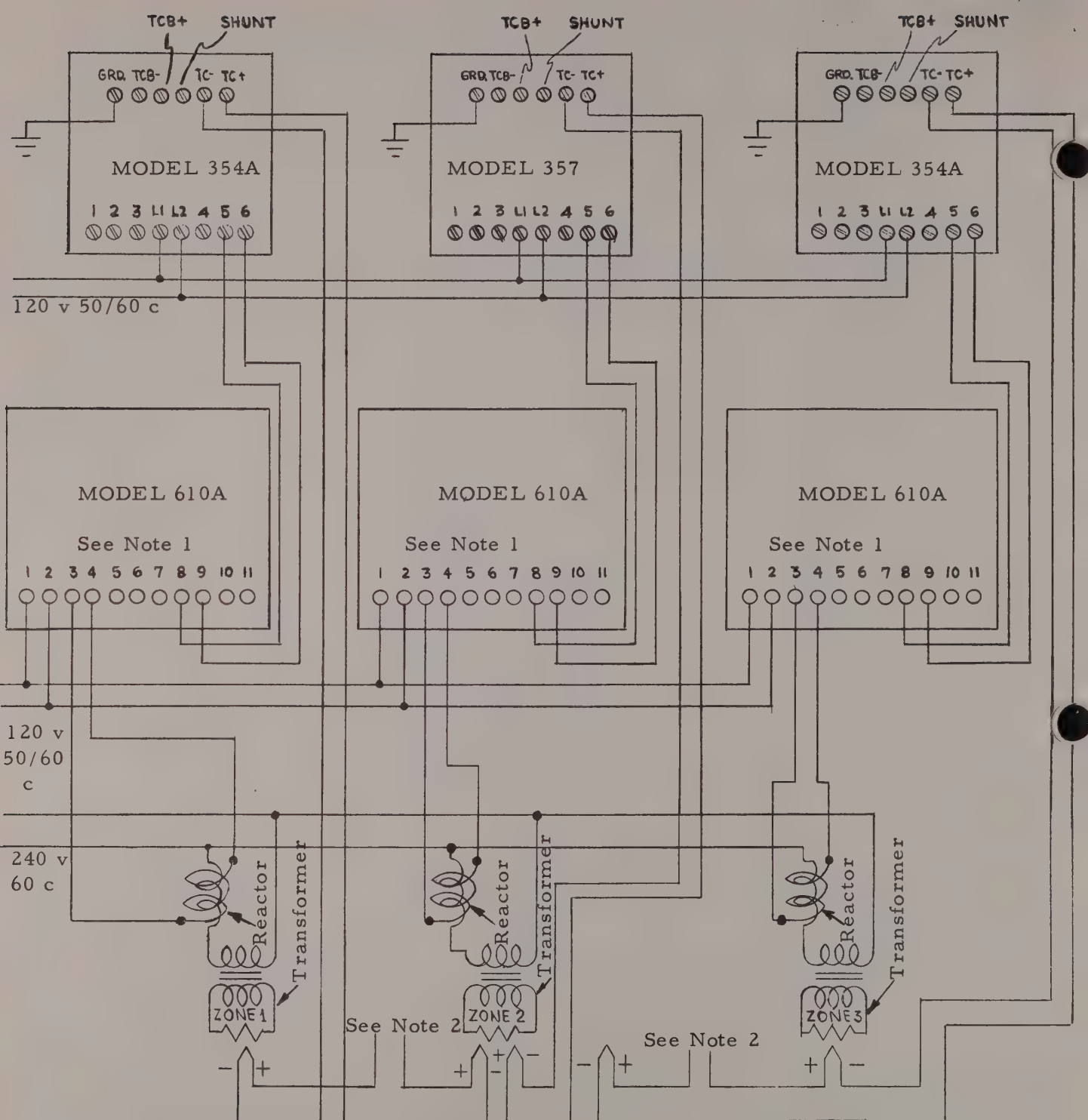


Figure 8
 External wiring diagram of a Model 354A connected with a
 Series 350 Reference Voltage Source and a Model 610A Pilot Amplifier
 driving a three-phase saturable reactor for null balance control



NOTES:

1. If impedance of reactor d-c control winding is over 70 Ω connect to terminals 6 and 7 of 610A. If under 70 Ω connect to terminals 3 and 4.
2. On standard models connect both positive thermocouple extension wires to TCB+ terminals. On models with electrical alignment option, make connections as shown in Figure 5, Page 11.

Figure 10

External wiring diagram showing the Model 354A used in a master-slave system with a Model 357 Digiset for differential control through a Model 610A Pilot Amplifier and saturable reactors

External Resistance

Since the Model 354A utilizes a null balance or differential arrangement in conjunction with a sensitive meter movement, the resistance of the thermocouple and leadwire has only a negligible effect on the controller. Such effect as it may have takes the form of altering slightly the response time or the sensitivity of the instrument. The greater the external resistance, the faster will be the meter response but with a decrease of sensitivity. In many applications, particularly with use of base metal thermocouples, additional resistance is added in series with the thermocouple input to increase the response of the meter (decreasing the response time). Sensitivity would be reduced a like amount. Unless otherwise specified, instruments are furnished with a resistance strip of zero resistance mounted between the two terminals on the back wiring panel. Other values of resistance for use with standard instruments are available from the factory. Instruments equipped with the optional alignment can use only the zero resistance strip. See next sub-section of this instruction.

Standard Models:

(Meters with mechanical alignment only)

To obtain critical damping (the point at which the meter will reach control point in the least possible time without overshoot), a 325 ohms resistance strip can be inserted in standard models of this instrument in series with the thermocouple. The response time of the unit is thus reduced from 5.5 seconds to 1.4 seconds. As stated previously, the added resistance will decrease the sensitivity. This means that the microvolts required to cause the meter indicator to deflect one scale division is increased.

The microvolts required to deflect the pointer one division can be determined from the nomograph (Figure 11). It is used in the following manner:

1. Determine the total thermocouple circuit resistance of the meter. This is the combined resistance of the meter coil (95 ohms), thermocouple and extension wire, and the resistance strip on the back of the instrument. If a reference voltage source is used, its resistance must also be added. Total resistance can be figured by adding the value of each of these elements, or else by measuring the external resistance with an ohmmeter. To do this, remove the meter assembly and attach the ohmmeter leads to the TC connector springs, and then add the 95 ohms coil resistance to the value measured.

2. With the total resistance then known, draw a line from that resistance value through point A, intersecting the $\mu\text{v}/\text{division}$ line, giving the microvolts per division.
3. If the degrees Fahrenheit or degrees Centigrade per division is desired, draw a line from the intersecting point on the $\mu\text{v}/\text{div.}$ line through point B, C or D, depending upon the thermocouple used, intersecting the $^{\circ}\text{F}$ or $^{\circ}\text{C}/\text{div.}$ line, thereby giving the Fahrenheit or Centigrade degrees per division.

The two examples shown neglect TC resistance and TC extension wire resistance. One example is for a meter with coil resistance only, which is 95 ohms, and the other example applies to a unit that is critically damped ($95 + 325$ ohms). The sensitivity is shown to be 66.5 and 294 $\mu\text{v}/\text{div.}$ respectively. If a Pt/Pt 13% TC were used, this would result in $4.9^{\circ}\text{C}/\text{div.}$ for the coil only and $21.5^{\circ}\text{C}/\text{div.}$ when the unit is critically damped.

See section on "Proportional Control" for the effective proportional band.

Models with Electrical Alignment Option:

On models of this instrument using the electrical alignment adjustment, the external resistance strip must be of zero ohms. Any different value of external resistance is not to be used since it would alter the bridge balance point and the electrical alignment adjustment.

The meter coil sensitivity is still 0.70 milliamps per division (as in all models), but because the meter assembly incorporates fixed values of bridge resistors, the nominal meter sensitivity is 160 $\mu\text{v}/\text{div.}$ and the nominal response time (at 63.3%) is 5 seconds.

The degrees Fahrenheit or degrees Centigrade per division can be obtained by referring to the nomograph, Figure 13. Draw a line from the 160 $\mu\text{v}/\text{div.}$ point through points B, C or D, depending on the TC used, gives the Fahrenheit or Centigrade degrees per division for meters with the electrical alignment option.

Thermocouple Break Protection

Although the rear terminal strip has provisions for thermocouple break protection (TCB), none is provided with this particular model. TCB is not used with most differential or null balance systems because of the error that is produced. If high temperature or thermocouple protection is desired, a monitoring device should be used such as a "Limitrol" Model 281L.

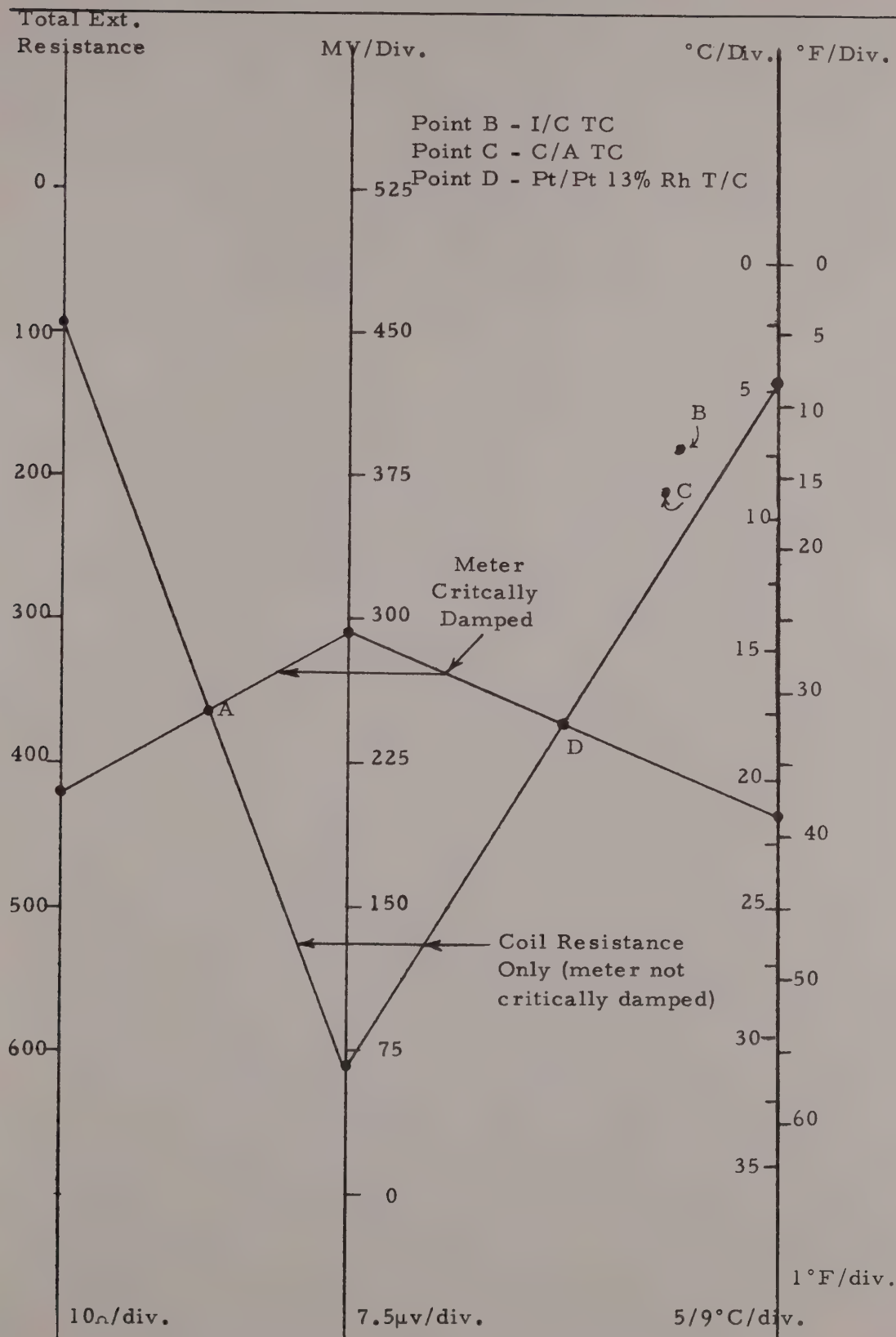


Figure 11
Nomograph of Meter Resistance vs Sensitivity

OPERATION

The meter indicator indicates the difference between two thermocouples or between a reference source and a thermocouple. When no difference exists the meter indicator coincides with the red arrows. The Model 354A has an instantaneous response because solid state devices operate without warm-up time. When the red signal light glows, the instrument is powered and the light will remain on until the power to the instrument is turned off. If a d-c voltmeter is connected across the test jacks, and with the output of the instrument connected to a controller, the voltmeter output will decrease when the meter indicator moves from left to right, approaching the red arrows. This is the region where proportional control action occurs.

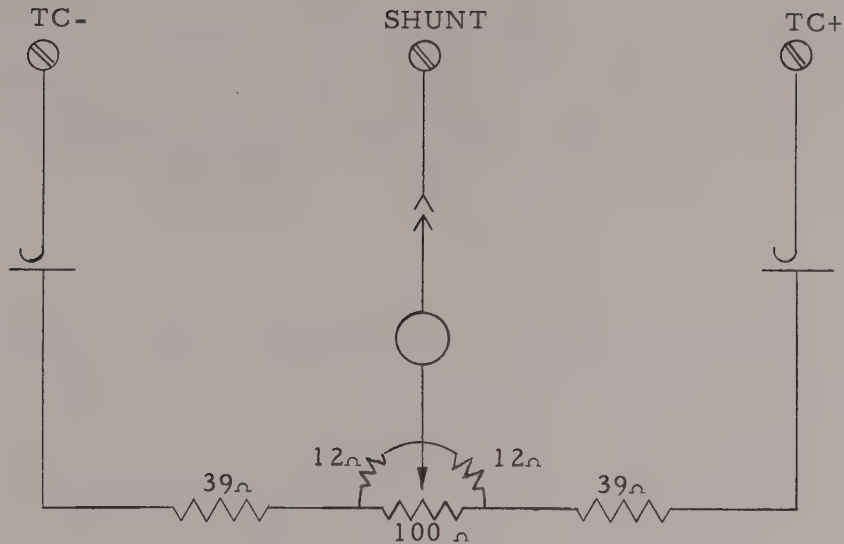
Meter Adjustment

Standard Models:

The only meter adjustment necessary on standard models of this instrument is to align the meter indicator with the points of the two red arrows on the meter scale. This is done by first disconnecting the thermocouple link (to the left -- just inside the front access cover) and then adjusting the alignment screw on the top of the instrument until the meter indicator coincides with the center of the meter scale indicated by the two red arrows. Turn the alignment screw slowly, allowing time at each turn for the indicator to reach equilibrium.

Models with Electrical Alignment Option:

An optional feature available on the Model 354A is an electrical alignment adjustment (the front knob) that can be used in conjunction with the mechanical adjustment (the screw on top of the meter) for aligning the meter indicator with the center of the meter scale indicated by the red arrows. The purpose of this adjustment is to compensate for any misalignment that may occur as a result of inherent inaccuracies of the two thermocouples. The unit is first adjusted with the thermocouple circuit disconnected, using the top adjusting screw to cause the indicator pointer and red arrows to coincide. See above. With the thermocouple circuit then connected but held at ambient or at the same thermocouple temperature, any offset then found between the indicator and the red arrows can be adjusted electrically by using the front knob. Turning the knob clockwise will move the indicator to the right and reduce the control chassis d-c output a corresponding amount. Turning the knob counterclockwise will move the indicator pointer to the left. See Figure 12.



Meter Wiring Schematic
Showing Electrical Alignment Adjustment
Figure 12

Control Adjustments

Final control adjustments should be made after the unit has been in operation 45 minutes and has obtained maximum stability. The controls are accessible by removing the front access cover, which is easily removed by pulling the small knob located below the control set point knob.

Proportional Band Adjustment

The proportional band (PB) adjustment is used to vary the proportional band from 2% to 16% of graduated scale length. Turning the PB adjustment clockwise will increase the PB, and counterclockwise will reduce it. The proper PB setting is obtained in the following manner:

With the PB adjustment fully clockwise (maximum), apply power to the controlled load. When the controlled load temperature has become thermally stable at a point near the red arrows in the center of the scale, turn the PB adjustment CCW slowly, decreasing the PB until the meter indicator or an external monitoring device indicates a noticeable cyclic variation. Then turn the PB adjustment CW in small increments, being sure to let the controlled load stabilize after each adjustment. The cyclic variations of the meter indicator and the load will decrease and the proper PB adjustment is obtained when no preceptible indicator movement occurs. With

this PB setting, temperature variations of the controlled load are minimized. If with the proportional band adjustment turned fully clockwise, adequate control cannot be obtained, the external resistance in the thermocouple has to be increased. See section on "Proportional Control" to determine the resistance value needed.

Reset

A "reset" adjustment is located on the left front of the plug-in control chassis. Reset adjustment provides a means of aligning the meter indicator with the red arrows to correct for offset. If the meter indicator does not coincide with the red arrows after the controlled load has become thermally stable, an adjustment should be made. Use a small screwdriver to reposition the reset adjustment capacitor. Turning the reset adjustment CCW will shift the meter indicator to the left. The reset adjustment should be in small increments with sufficient time allowed after each adjustment to permit the controlled load to again become thermally stable. The proper reset adjustment occurs when the meter indicator coincides with the red arrows when the load is thermally stable.

MAINTENANCE

Maintenance and Service Checks

The 354A instrument is well designed and manufactured of high grade components and with normal care will give uninterrupted service for a long time. It is good practice, however, to have information as to service and spare parts for emergency servicing. Where a number of instruments are located together, the plug-in parts are interchangeable to allow minimum inventory.

When trouble is encountered, the service man should familiarize himself with the process and instrument application to determine the exact function of the instrument as applied. The instrument trouble usually can be traced to two basic problems: measurement or control.

Measurement trouble can be detected by observing the pointer position. If the measurement is known to be in error, check the following:

1. Open or broken thermocouple, extension wire or connector.
2. Deteriorated thermocouple. Compare readings with a test thermocouple.
3. In most applications the thermocouple is grounded through the furnace or machine to which it is attached. If this is not the case run a wire from TCB+ terminal to the ground terminal on the rear of the instrument and ascertain that the instrument is also grounded. (NOTE: In case the thermocouple is directly in contact with a heater or a similar electrical load, a 2 mfd, 200 volt capacitor should be connected between terminal TCB+ and ground).
4. Accidental shorts, grounds, or moisture in the extension wire (especially with asbestos type insulation).
5. High resistance in leads due to loose connectors, poor splicing, dirty switch contacts, and other faulty connectors.
6. Problems caused by vibration or shock.
7. Errors due to oil or grease. Do not oil or grease any part of the instrument.
8. Incorrect alignment adjustment. The correctness of this setting should be checked following any meter servicing.

Control trouble may be detected by observing indicator pointer position with respect to the red arrows. If control action does not occur at the red arrows, do the following:

1. Check electrical connectors and correctness of line voltage. Ascertain as to whether trouble is internal or external to the instrument.
2. Determine if instrument, magnetic amplifier or power controller are powered; check load power for open circuits and open legs in three-phase circuits.
3. Check the supply voltage to the components. It should be within $\pm 10\%$ of rated line voltage. Excessive line voltage variations can cause large fluctuations in load power.
4. Check to see if the reactor rating is compatible with the load rating.
5. Check the output of the Model 354A by connecting a d-c voltmeter to the instrument's test terminals to measure the instrument's output. When the black indicator is well to the left of the red arrows, the meter reading should be greater than 18 volts d-c. When the black indicator is to the right of the red arrows, the test meter should read 3 volts d-c or less.
6. If the instrument output is low (less than 18 volts d-c) when the indicator is considerably to the left of the red arrows, check for improper reset adjustment.
7. If there is no power applied to the load with the instrument energized, attach a d-c voltmeter to the test jacks. If the voltmeter indicates zero output, make sure the meter indicator is well to the left of the red arrows and then turn the reset adjustment through its entire adjusting range. If the d-c voltmeter then indicates an output to the controller, let the controlled load stabilize and then make an adjustment of reset as described under "Control Adjustments". If the instrument does not then function, further servicing or replacement of the control chassis is suggested.
8. If cycling is present at maximum proportional band, see section on "Proportional Control".

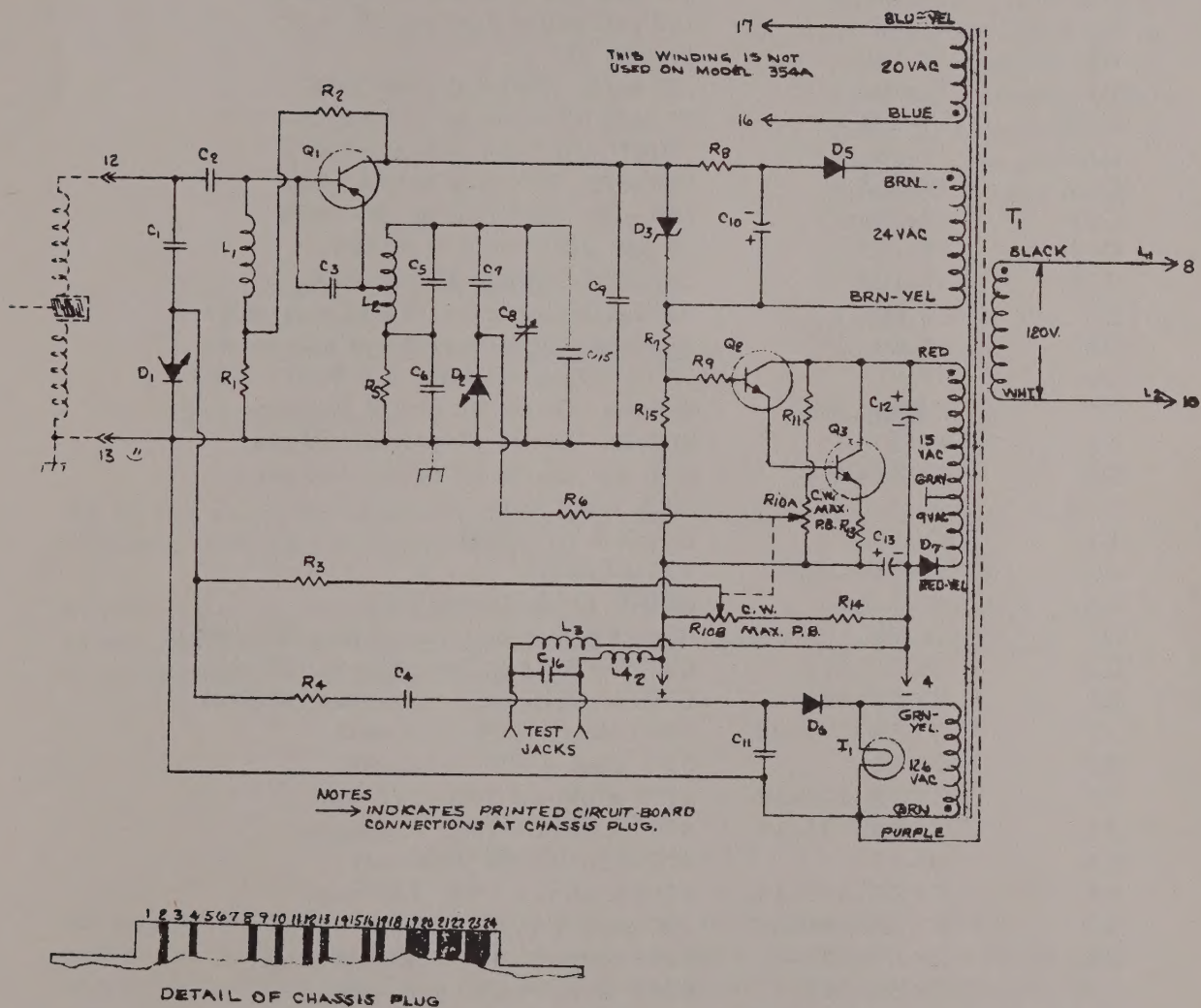


Figure 13
Model 354A
Internal Wiring Schematic
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PARTS LIST

<u>Item</u>	<u>Part No.</u>	<u>Description</u>
C1	39-69	100 pfd 600 v d-c w $\pm$ 5% NPO
C2	39-203	270 pfd 600 v d-c w $\pm$ 5% NPO
C3	39-212	8 pfd 500 v d-c w $\pm$ 10% N4700
C4	39-88	.0047 mfd 1000 v d-c w GMV
C5	39-80	47 pfd $\pm$ 10% 600 v d-c w NPO
C6	39-203	270 pfd 600 v d-c w $\pm$ 5% NPO
C7	39-69	100 pfd 600 v d-c w $\pm$ 5% NPO
C8	39-160	2.9-35 pf
C9	39-103	.01 mfd 1000 v d-c w GMV
C10	39-153	50 mfd 50 v d-c w -10 +150%
C11	39-88	.0047 mfd 1000 v d-c w GMV
C12	39-163	100 mfd 50 v d-c w -20 +80%
C13	39-163	100 mfd 50 v d-c w -20 +80%
C15	39-155	10 pfd 600 v d-c w N1400
C16	39-103	.01 mfd 1000 v d-c w GMV
D1	37-60	Variable Capacitor 33 pf at 4 volts
D2	37-60	Variable Capacitor 33 pf at 4 volts
D3	37-61	12 volt Zener Diode 3/4 Watt $\pm$ 10%
D5	EYZP-384	Silicon Diode 80 piv at 100 ma
D6	37-30	Silicon Diode 60 piv at 50 ma
D7	EYZP-384	Silicon Diode 80 piv at 100 ma
I1	36-34	12.6 volt Bulb
L1	41-133	22 μ H $\pm$ 10% Coil
L2	41-130-100	1.2 μ H Coil
L4	41-124	60 μ H $\pm$ 10% Choke Coil
Q1	31-50	High Frequency Transistor (2N2188)
Q2	EYZP-439	600 mw Silicon Transistor (2N696)
Q3	EYZP-439	600 mw Silicon Transistor (2N696)
R1	CYZR-170-22	1000 ohm $\pm$ 10% 1/2 watt
R2	40-82	33 k ohm $\pm$ 10% 1/2 watt
R3	CYZR-170-18	4700 k ohm $\pm$ 10% 1/2 watt
R4	CYZR-170-18	4700 k ohm $\pm$ 10% 1/2 watt
R5	40-77	270 ohm $\pm$ 10% 1/2 watt
R6	CYZR-170-18	4700 k ohm $\pm$ 10% 1/2 watt
R7	CYZR-170-47	330 ohm $\pm$ 10% 1/2 watt
R8	CYZR-133-2	1500 ohm $\pm$ 10% 1/2 watt
R9	CYZR-105	8200 ohm $\pm$ 10% 1/2 watt
R10A	29-148	100 k ohm $\pm$ 10% 1/2 watt Pot
R10B	29-148	100 k ohm $\pm$ 10% 1/2 watt Pot
R11	40-70-2	47 k ohm $\pm$ 10% 1/2 watt
R13	40-78	15 ohm $\pm$ 5% 1/2 watt
R14	40-70-2	47 k ohm $\pm$ 10% 1/2 watt
R15	CYZR-170-36	680 ohm $\pm$ 10%
T1	30-144	Power Transformer
L3	41-124	60 μ H $\pm$ 10% Choke Coil

SUGGESTED REPLACEMENT PARTS TO KEEP ON HAND

<u>Quantity</u>		<u>Part Number</u>
2	MAZDA Pilot Lamps	36-34
1	Replacement Thermocouple	Barber-Colman can supply thermocouple assemblies, components or wire for any requirement you may have. If need be, delivery will be made in 48 hours. Contact your nearest Barber-Colman field office.
1	Indicating Meter Assembly	
	Standard	A-6315
	With Electrical Alignment Option	A-6315-100
1	Control Chassis	A-5988-100

We do not recommend electronic component replacement except by well equipped instrument repair shops.

Barber-Colman, Industrial Instruments Division, maintains service and repair facilities in many major cities in the United States and Canada. Consult your yellow page directory.

MATERIAL WARRANTY

All equipment except tubes, photocells, and thermocouples, which within one year from date of shipment is found to have been originally defective, will be repaired (replaced if necessary) free of charge, if returned immediately, pre paid, to the factory at Rockford, Illinois. The seller shall not be liable to the purchaser, or to any other person, firm or corporation for any direct, indirect or consequential damages or injury of any kind or character; that by acceptance of such equipment the purchaser shall accept and assume all liability for any and all damages or injuries that may result from the use or misuse of such equipment by the purchaser, or by any other person, firm or corporation; and that there shall be no other warranty whatever, expressed or implied, with respect to such equipment.

